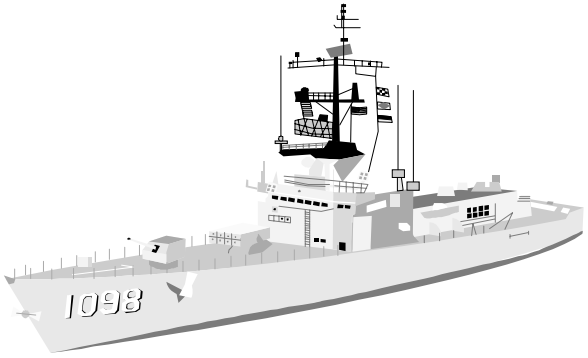
Navy Fuel Cell Programs

Steven R. Satzberg
Office of Naval Research



Joint Fuel Cell Technology Review Conference
3-5 August 1999, Chicago, IL

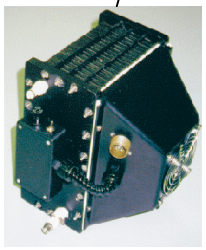
Objective

Demonstrate near term affordable ship service fuel cell power systems operating on *naval logistics fuel* and develop high power, high efficiency advanced systems with potential for future propulsion applications.

Fuel Processing Requirements

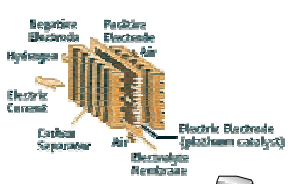
Low → **High**

Hydrogen	Methanol	Natural Gas	Gasoline	Diesels

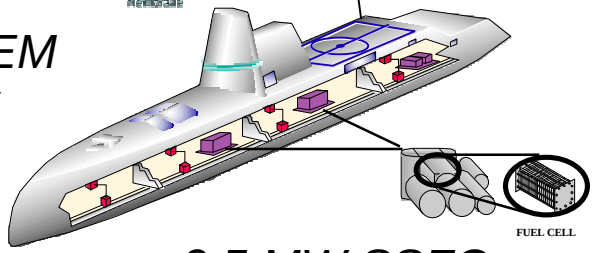


Personnel Portable

Consumer EV

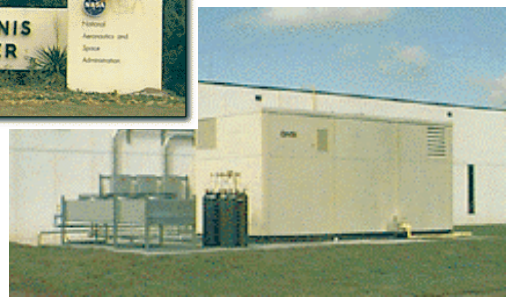


50 kW PEM for EV



2.5 MW SSFC

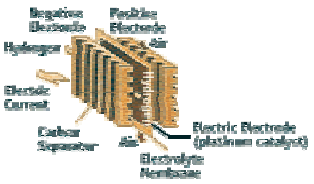
Public Transportation



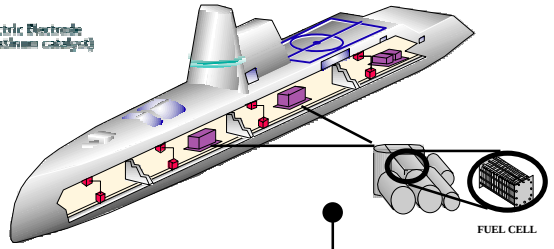
200 kW at 50% Efficiency

Mississippi NAVOCEANO Distributed Power Generation

Fuel Cell Power Ranges



SSFC



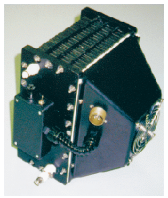
UUV/MCM

10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7

Power (Watts)

MEMS

“BA5590”



Home Electricity

UAV

SSN Emergency Power

Navy Fuel Cell Execution Plan

Applied Research

- FC Models
- Surface Ship Impact Assessments
- Small Scale Technology Development (Cells, Fuel Reforming, etc.)

Reduced-Scale Demonstration

Phase I: (FY97-00)

- 2.5 MW Ship Service Fuel Cell Power Plant Design
- Critical Component Risk Reduction Demonstration (i.e. Shock, Vibration, Salt Atmosphere)
- Trade-off Studies to Optimize System Design
- Technical, Cost & Schedule to Build 0.5 MW Reduced-Scale Demonstrator

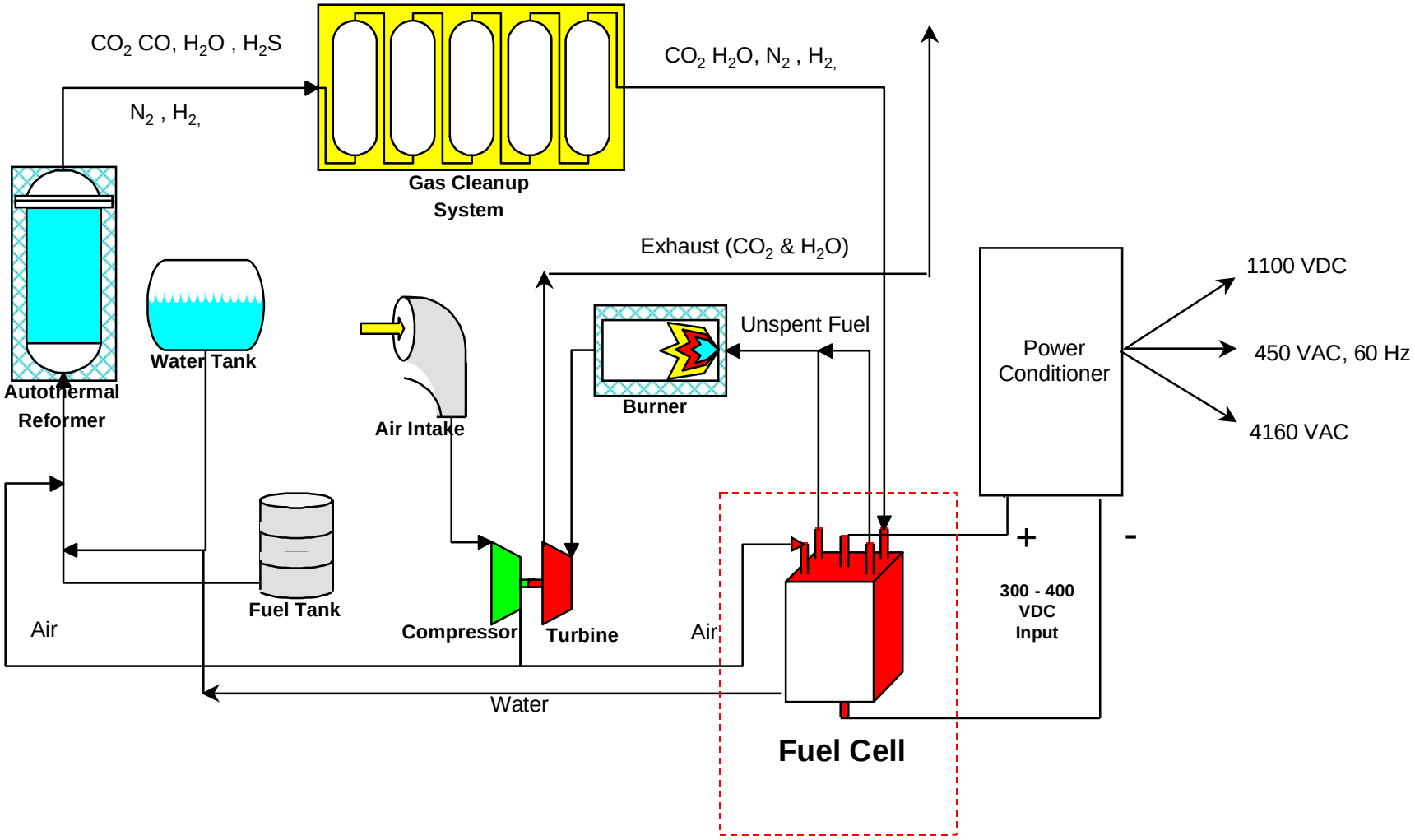
Phase II: (FY00-03)

- Design and Build 0.5 MW Reduced-Scale Demonstrator
- Land-Based Testing for Design Validation

Phase III: (FY03-04)

- Perform At-Sea Demonstration
- Dynamic Computer Model
- Complete Design Drawings/Specs for 2.5MW SSFC

Concept

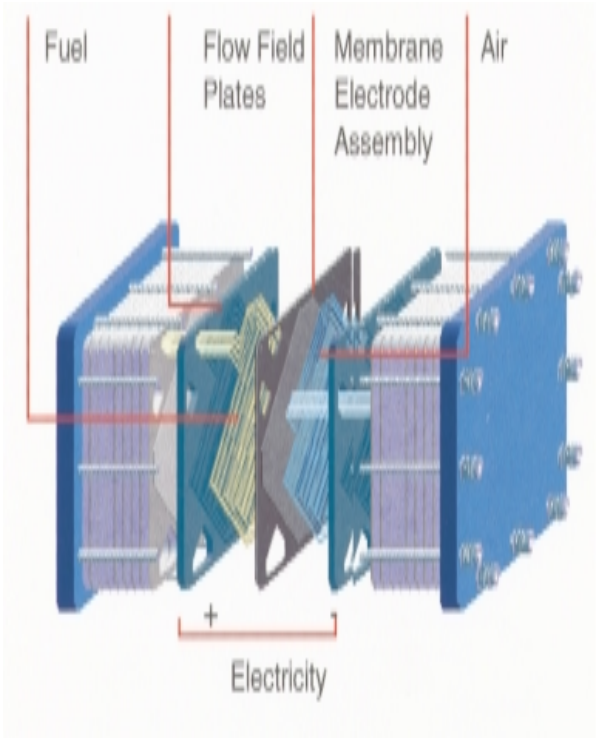

CO_2 CO, H_2O , H_2S
N_2 , H_2,
CO_2 H_2O, N_2 , H_2,
Gas Cleanup System
Exhaust (CO_2 & H_2O)
Autothermal Reformer
Water Tank
Air Intake
Burner
Unspent Fuel
Power Conditioner
1100 VDC
450 VAC, 60 Hz
4160 VAC
Air
Fuel Tank
Compressor
Turbine
Air
+
-
300 - 400 VDC Input
Water
Fuel Cell

Fuel Cell Technologies

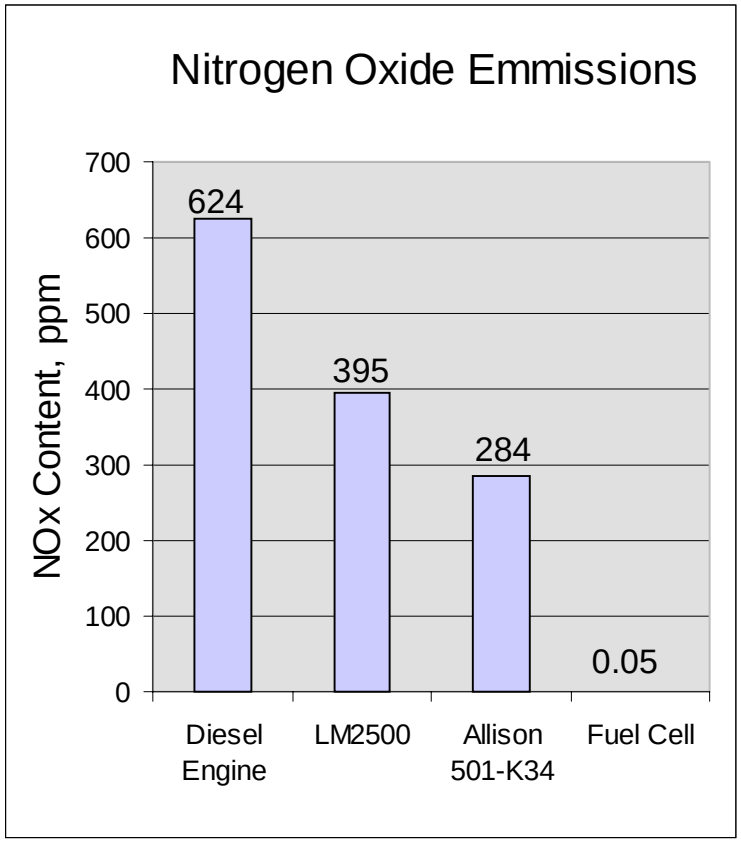
ERC Molten Carbonate Fuel Cell

Single MC Stack from 2.0 MW Demo

MTI/Ballard PEM Fuel Cell



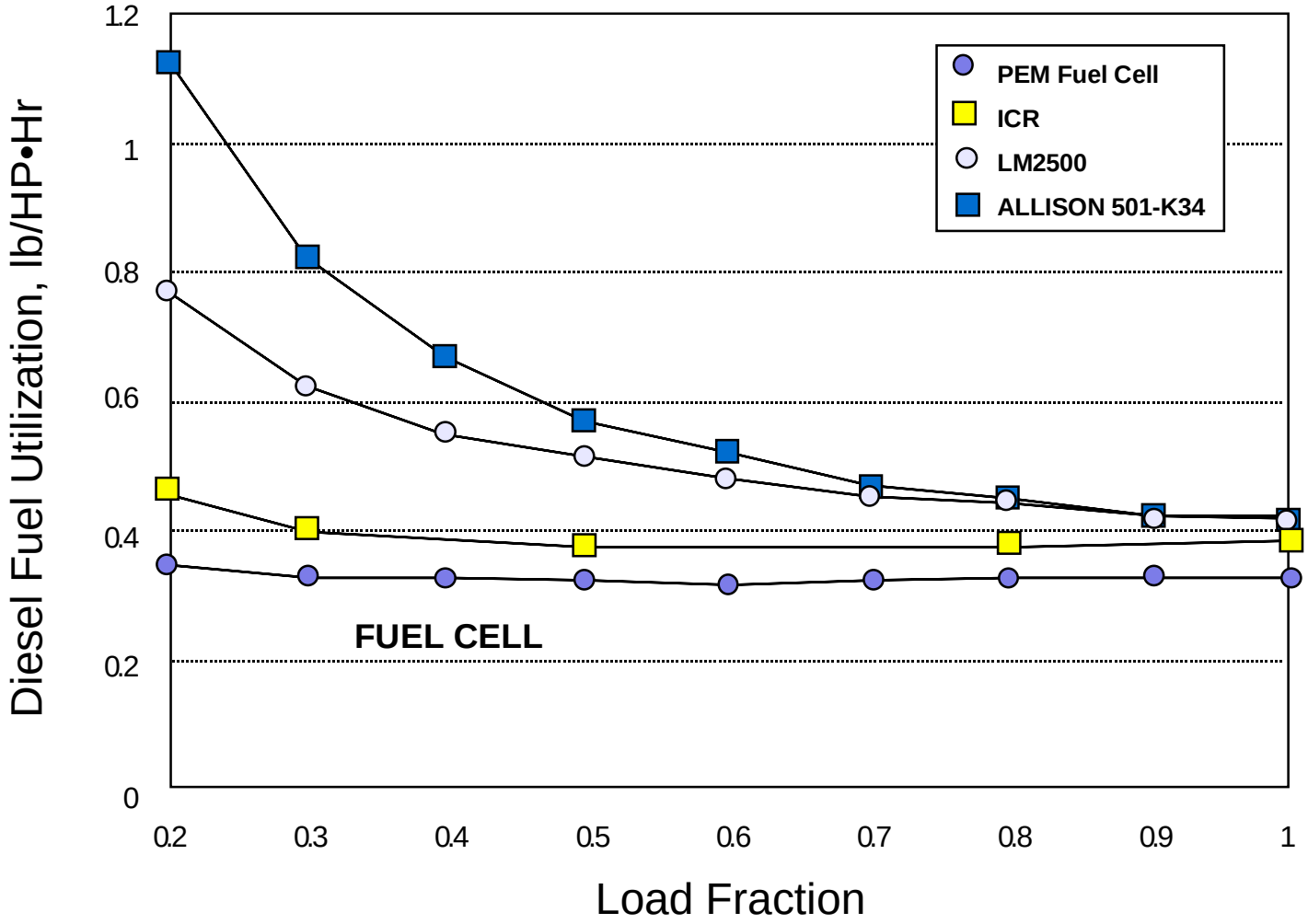
Fuel Cells for Shipboard Power



Operate with Higher Efficiencies and at Lower Temperatures

- ✔ 96% Reduction in NO_x, CO and HC Emissions
- ✔ 30% Reduction in CO_2 Emissions
- ✔ $0.6M to $1M/yr/ship Savings
- ✔ >75% Cooler Exhaust
- ✔ 60% Reduced Stacks

Fuel Rate Comparison (Electrical Power Output)



Technical Challenges

- **Fuel Type & Efficiency**
- **Reliability and Maintainability**
- **Duty Cycle**
- **Transient Response**
- **Power Density & Cost**
- **Cell Life**
- **Marine Environmental Contaminants**
- **Shock & Vibration**
- **Ship Motions**

Interagency Work Group

NAVY

Chief of Naval Operations
Naval Sea Systems Command
Office of Naval Research
Naval Surface Warfare Center, Annapolis Detachment

NON-NAVY

Department of Transportation
U.S.Coast Guard
Maritime Administration
Research and Special Projects Administration

Department of Commerce
National Oceanic and Atmospheric Administration

Department of Energy
Office of Fossil Energy

OTHER FEDERAL AGENCIES

Federal Railroad Administration
Federal Transit Administration

Summary

- DoN leveraging commercial programs
- DoN addressing unique marine issues (fuel, shock, vibration, etc.)
- Current program sponsored by ONR to provide 500 kW at-sea demonstrator